Energy Policy 88 (2016) 216–228

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Assessing drivers and barriers of energy-saving measures in Oklahoma's public schools

Becca Castleberry, Travis Gliedt*, J. Scott Greene

Department of Geography and Environmental Sustainability, University of Oklahoma, SEC 634, 100 East Boyd Street, Norman, OK 73019, United States

HIGHLIGHTS

- Energy performance improvements depend on characteristics of a school district.
- Districts with environmental science classes more likely to take energy measures.
- Cost savings motivated energy measures in high-income/large-population districts.
- A cluster analysis revealed geographic patterns of energy saving measures.

ARTICLE INFO

Article history:
Received 7 July 2015
Received in revised form
12 October 2015
Accepted 13 October 2015

Keywords:
Energy efficiency
Energy conservation behaviors
Oklahoma
Technology
Sustainability

ABSTRACT

Implementing energy conservation initiatives within public schools, including both behavioral changes as well as building retrofits, can generate cost saving and educational benefits. However, the level of energy efficiency improvements that can be achieved may depend on the socio-economic characteristics of the school or the underlying district. The purpose of this research is to identify and examine the factors that have a role in influencing the adoption of energy-saving practices and/or building retrofits within Oklahoma's public schools. In order to investigate these factors, a survey was administered to public school administrators across the state. The results illustrate different factors that drive schools to make decisions associated with energy conservation and retrofitting efforts. A comparative analysis between different types of schools (e.g., rural vs. urban, low- vs. high-income) was also conducted to discover the combination of characteristics that are associated with energy-saving measures. The findings could help school administrators and teachers understand how they might adopt new behaviors or technologies.

1. Introduction

Energy conservation is important to public schools because of the potential benefits that could be generated for the schools and the surrounding community. For example, schools faced with shortages in funding could realize financial benefits from savings on energy costs. Energy savings can either be realized through behavioral changes such as turning off lights and computers when not in use, or through technological solutions that improve efficiency such as upgrading the lighting system to more efficient LED lights. Both behavioral and technological approaches to energy conservation could be employed within schools. Challenges related to the cost of technology upgrades can be one barrier. However, behavioral changes typically have no or low associated costs. Depending on certain characteristics of a particular school or district, the types of conservation efforts adopted may differ.

Oklahoma provides a solid landscape for studying energy conservation in schools for a number of reasons. First, the majority of the state of Oklahoma falls within the temperate and humid climate zone, and thus, schools will require similar types of retrofits (e.g., cooling systems, window glazing) (US Department of Energy, 2002). Furthermore, Oklahoma's average annual household income ranks 37th in the nation at just under $48,000 (US Census, 2015a), and is significantly lower in rural counties. This suggests that energy measures in public schools in some counties may need to be cost effective and have low up-front costs to be feasible, unless they are funded by federal or state programs. These characteristics of Oklahoma provide a unique contextual backdrop for studying energy conservation in public schools.

1.1. Energy-saving measures in schools

Energy conservation measures in schools can take the form of behavioral changes or technology changes. Behavioral changes can

* Corresponding author.
E-mail addresses: Becca.C.Castleberry-1@ou.edu (B. Castleberry), tgliedt@ou.edu (T. Gliedt), jgreene@ou.edu (J.S. Greene).

http://dx.doi.org/10.1016/j.enpol.2015.10.010
0301-4215/

be influenced by a variety of factors (Aktamis, 2011; DeWaters and Powers, 2011; Higgs and McMillan, 2006; Schelly et al., 2011, 2012; Zografakis et al., 2008). Aktamis (2011), for example, emphasized that socio-demographic characteristics of students may determine their energy-saving behaviors. A study of a successful energy education project in Greece showed that education in energy-related issues can result in energy-saving behaviors among students and parents (Zografakis et al., 2008). Additionally, they found that "energy squandering could be better remedied by education and legislation rather than advanced technological solutions" (Zografakis et al., 2008, 3227). Other studies either produced similar findings or stressed the need for energy education programs within schools to promote energy awareness and subsequent behavioral changes (DeWaters and Powers, 2011; Schelly et al., 2011).

The idea of a "conservation culture" through demonstrating and learning from energy behaviors is another key way that schools may achieve energy-savings (Higgs and McMillan, 2006; Schelly et al., 2012). These studies showed that teachers and administrators have the ability to influence students' behaviors related to conservation and knowledge of energy issues. Additionally, it has been shown that students can also learn these concepts and behaviors from other students, as well as teachers learning these practices from students (Schelly et al., 2012).

Though behavioral changes are cost-effective for energy conservation, technological approaches such as building retrofits can potentially yield significant energy-savings. Dall'O' et al. (2013), Dequaire (2013), Dimoudi (2013), and Hong et al. (2012) emphasized the role of implementing building retrofits in order to conserve energy and to foster a better learning environment for the school's occupants. Hong et al. (2012) conducted a study within schools in South Korea that sought to determine the most economically effective building retrofits that also reduce the building's carbon dioxide emissions. They concluded that very few retrofits are economically viable for schools due to cost barriers, but upgrading the building's lighting to light emitting diode (LED) systems would be the most economically feasible. The findings of Dall'O' et al. (2013) and Dequaire (2013) differed in their conclusion that many types of retrofits (e.g., upgrading the HVAC system, or improving insulation) have significant energy-saving potential as well as the possibility to cut schools' energy costs significantly.

A report from the US Department of Energy outlined the economic benefits of implementing certain types of retrofits within school buildings (US Department of Energy, 2002). This report consisted of several case studies that described the type of retrofit (s) the particular school implemented, the initial cost, and the annual savings. For example, Durant Road Middle School located in Raleigh, North Carolina implemented a daylighting retrofit. According to the report, the net cost of this was $115,000 and the annual savings were $77,000 (US Department of Energy, 2002). Another example of a cost-effective retrofit was the installation of a geothermal heating and cooling system at Daniel Boone High School located in Gray, Tennessee. The initial cost of the system was $197,000 with savings of $62,000 annually (US Department of Energy, 2002). Additional examples of cost effective energy efficiency programs in K-12 schools from across the United States (US Environmental Protection Agency, 2011), as well as a recent study by Gliedt and Hoicka (2015), highlight that many energy upgrades in US schools were conducted as a financial investment with the expectation of a financial return within a reasonable payback period.

1.2. Education policy as a barrier to implementation

Although implementing energy-saving measures at both behavioral and technological scales has value to schools, there are often barriers that must be overcome. Possible barriers to the implementation of these practices can be found in educational standards and the current state of science, technology, engineering, and mathematics (STEM) education. Tenam-Zemach (2010) sought to assess the role of national, state, and local standards in promoting understanding of sustainability issues. Through researching the presence and context in which specific indicators (e.g., climate change, biodiversity, human population density, impact and presence of environmental pollution, and earth as a closed system) were present within education standards, Tenam-Zemach (2010) found that these particular indicators were largely approached from an anthropogenic perspective. This suggests that the "conservation culture" through teaching these concepts could be better optimized with a more "STEM" focused approach.

Tenam-Zemach (2010) illustrates problems found within national standard. Sustainability-related education is also somewhat underemphasized when examining the Oklahoma Priority Academic Student Skills (PASS Standards, 2011) standards. These standards are organized according to grade level from grades one to eight, and organized by course at the high school level. Up until grade five, the focus of earth science topics is largely on the scientific aspects of this subject. For example, one standard for third grade focuses on organisms and environments and is as follows, "All living things have structures that enable them to function in unique and specific ways to obtain food, reproduce, and survive" (PASS Standards, 11). While there is certainly value in learning these topics, the topic of human impact upon the environment is not explicitly stated until grade five. This standard is as follows; "changes in environmental conditions due to human interactions or natural phenomena can affect the survival of individual organisms and/or entire species" (PASS Standards, 2011, 18). More recently, the state has moved away from PASS standards to Oklahoma Academic Standards (OAS, 2014). These standards focus more on the human impact upon the environment before grade five. For example, a learning objective mentioned in the standards for first grade is, "Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impact on the land, water, air, and other living things" (OAS, 2014, 28). Although the OAS are more recent, it is useful to examine the PASS standards as they were in place for approximately 20 years before the state transitioned to OAS.

There may also be issues with the way the OAS and PASS standards are organized by course at the high school level. The standards for environmental science courses are in line with topics related to sustainability. Typically, energy-related topics and issues are one focus of sustainability. One of the standards for these courses is as follows; "people are capable of reducing and reversing their impact on the environment because they can think, plan, and educate…a variety of methods are used to analyze the sustainability of current trends in world population growth and natural resource consumption (e.g., carrying capacity, ecological footprints)" (PASS Standards, 2011, 67). Similarly, an objective for environmental science outlined by OAS is that "the sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources" (OAS, 2014, 234). Environmental science courses address many sustainability- or energy-related topics, which may not be taught in schools that do not have environmental science courses. Although the extent that these topics are taught in the classroom may not directly influence a school to implement energy-saving measures, it could be an indicator of the school's openness to and awareness of such measures. Chedid (2005) suggested that improved STEM education within schools is an effective way to solve current and future energy challenges. Furthermore, Chedid (2005) argued that improved STEM education will foster creative development of technological solutions to future energy challenges as well as creating citizens who are overall more informed about energy-related